

Life histories and systematics of the Western North American Gobies *Lythrypnus dalli* (Gilbert) and *Lythrypnus zebra* (Gilbert)

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Abstract.—Life history investigations of *Lythrypnus dalli* and *Lythrypnus zebra* were conducted primarily on rocky reefs at Punta Banda, Baja California, Mexico, at depths of 3 to 53 m. Both species are common, but *L. zebra* tends to remain in less exposed situations and to be less numerous. Crustaceans, primarily copepods, are the major food of each species. Each species was parasitized by acanthocephalans, and by cymothoid isopods. The sex ratio among adults was 1 male to 1.61 females in *dalli* and 1:1.09 in *zebra*. Length-frequency distributions indicate two age classes in each species. Each species breeds within the first year and has a two-year life span. Males average larger than females: ripe females exceeded 22.0 mm in *dalli* and 20.7 mm in *zebra*; mature males exceeded 23.0 mm in *dalli* and 18.4 mm in *zebra*. Ripe individuals were present from March (in *dalli*) or April (in *zebra*) through October (in each species). *Lythrypnus dalli* tends to lay more eggs than *zebra* (1058 vs. 627). Eggs of *dalli* are deposited in empty mollusk shells of the reef epibiose or in unattached shells on the floor of the goby's shelter, whereas the eggs of *zebra* are attached to the roof of the shelter or to empty mollusk shells. Sexual dimorphism is evident in the fins and genital papilla.

The goby genus *Lythrypnus* is well represented in tropical and subtropical inshore waters of the eastern Pacific and western Atlantic. Most species are small, brightly colored, and have bars on the head and body. The bluebanded goby, *Lythrypnus dalli* (Gilbert), is bright coral-red with 5 to 9 blue bars on the anterior part of the body (Fig. 1). The zebra goby, *Lythrypnus zebra* (Gilbert), is cherry-red to brick-red, with 13 to 18 narrow blue bars on the head and body (Fig. 2). *Lythrypnus dalli* is readily distinguished from *L. zebra* by having higher meristic counts and fewer and wider bars on the body. Both are common inhabitants of rocky reefs along the coasts of southern California and Baja California, Mexico. Pequegnat (1964) found *dalli* to be the most abundant fish in the rock-reef formation at Corona del Mar, California, and *zebra* to be less common. Despite their abundance and the intriguing problem of niche specificity, little is known of the biology of these gobies.

STUDY AREA

Lythrypnus dalli and *L. zebra* were studied in the field simultaneously with the bluespot goby, *Coryphopterus nicholsii* (Wiley, 1973), from September 1966 through September 1969. Observations and collections were made primarily on the northeastern side of Punta Banda, Baja California, Mexico. Study reefs varied from 6 to 20 m in depth. Collections were also made in California at La Jolla, San Diego Co.; at San Clemente and Laguna Beach, Orange Co.; and at Palos Verdes and Santa Catalina Island, Los Angeles Co. Other collections were made in Baja California, Mexico at San Quintin and Islas Todos Santos.

METHODS AND MATERIALS EXAMINED

SCUBA was used in making observations and collections. Specimens were collected with "Chem-Fish" or with a slurp gun. The Punta Banda population was sampled at monthly intervals from July 1967 through September 1969 between

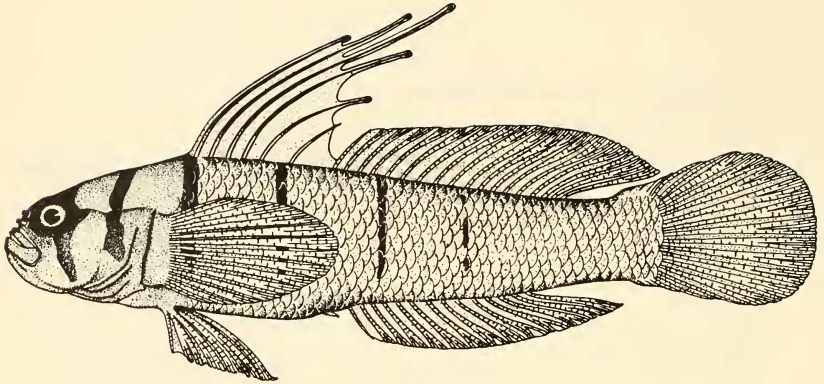


Figure 1. Bluebanded Goby, *Lythrypnus dalli* (Gilbert). Male, 38.3 mm S.L., from Punta Banda, Baja California, Mexico.

1100 and 1400 hrs. Other collections were made irregularly between September 1966 and June 1967. Methods of counting serial parts and taking measurements follow those of Hubbs and Lagler (1958), except that the caudal-ray counts follow the methodology of Ginsburg (1945). The last two ray bases of the dorsal and anal fins were counted as one ray. All measurements were taken with dial calipers to the nearest 0.1 mm. Proportions, obtained arithmetically, are presented as ranges and means. All measurements of body length are standard lengths (S.L.).

Museum specimens examined were from the collections of Stanford University (SU); California Academy of Sciences (CAS); Scripps Institution of Oceanography (SIO); University of California, Los Angeles (UCLA); and Los Angeles County Museum of Natural History (LACM).

Detailed tables of morphometric and meristic comparisons between populations of *L. dalli* and *L. zebra* have not been included in this paper, as I found no differences in the morphometrics and meristics which would warrant systematic recognition in either species. Copies of the tabular material (Tables 1-5) have been filed at the Carl Hubbs Library at Scripps Institution, Los Angeles County Museum, National Museum of Natural History—Smithsonian Institution, and the San Diego Natural History Museum. The material has also been deposited with the ASIS National Auxiliary Publications Service (NAPS)^{1/}.

BLUEBANDED GOBY *Lythrypnus dalli* (Gilbert)

Gobius dalli.—Gilbert, 1890: 50, 73-74 (original description; off San José Island, Mexico, and Catalina Harbor, Catalina Island, California; 33 fm., 35 fm.). Eigenmann and Eigenmann, 1892: 354 (San Pedro, California). Jordan and Evermann, 1896: 458 (Catalina Harbor, Catalina Island, California; listed). Jordan and Evermann, 1898: 2230-2231 (description; Catalina Harbor, Catalina Island, California; 35 fm.). Rutter, 1904: 253 (6 specimens from San José Island, Gulf of California, Mexico; largest 1.4 inches long). Fowler, 1923: 293 (Isthmus Harbor, Catalina Island, California; listed). Koumans, 1931: 114 (description of genus *Lythrypnus* using *Gobius dalli* as type).

Lythrypnus latifascia.—Ginsburg, 1939: 54 (description of new species; holotype—Fisherman's Cove, Catalina Island, California; female—22 mm long; compared with *Lythrypnus dalli*). Ginsburg, 1945: 137 (caudal fin ray count).

Microgobius cinctus.—Nichols, 1952: 4-5, fig. 2 (description of type, paratype; Carmen Island, Gulf of California, Mexico). Birdsong, 1967: 466-467 (*Microgobius cinctus* a junior synonym of *L. dalli*).

^{1/}See NAPS Document #02878 for 11 pages of supplementary material. Order from ASIS/NAPS, Microfiche Publications, P.O. Box 3513, Grand Central Station, New York, New York 10017. Remit in advance \$3.00 for microfiche copy or \$5.00 for photocopy. All orders must be prepaid. Institutions and organizations may order by purchase order. However there is a billing and handling charge for this service. Foreign orders add \$3.00 for postage and handling.

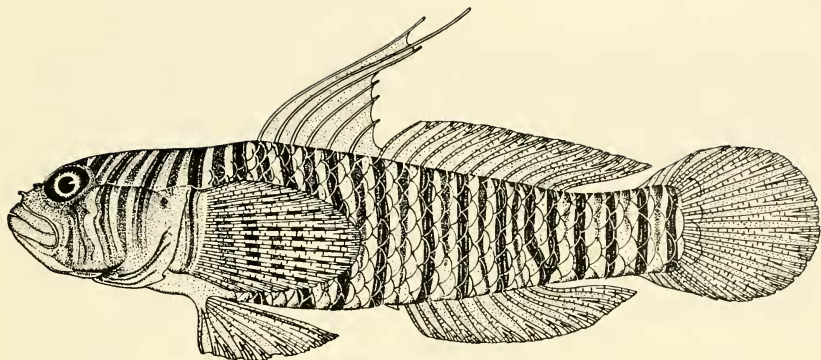


Figure 2. Zebra Goby, *Lythrypnus zebra* (Gilbert). Male 37.5 mm S.L., from Punta Banda, Baja California, Mexico.

Lythrypnus dalli.—Starks and Morris, 1907: 224-225 (Gulf of California, Mexico; Catalina Island and San Pedro, California; abundant in Catalina Harbor; description). Ulrey and Greeley, 1928: 20 (Catalina Harbor and Isthmus Harbor, Catalina Island; Gulf of California, Mexico). Jordan, Evermann and Clark, 1928: 442 (Catalina Harbor, Catalina Island, California). Ulrey, 1929: 10 (listed). Barnhart, 1936: 82, fig. 246 (description; Catalina Island, California; tide pools to about 300 feet; rare). Ginsburg, 1939: 53-54 (restriction of *Lythrypnus dalli*; description; comparison with *Lythrypnus latifascia* (n. sp.); lectotype, Gulf of California, Mexico). Fowler, 1944: 517, 582 (San José Island, Gulf of California, Mexico; listed). Ginsburg, 1945: 136-138, table II (caudal fin-ray count). Fitch, 1947: 191 (Emerald Bay, Santa Catalina Island, California; 20 feet). Hubbs and Follett, 1953: 34 (listed). Limbaugh, 1955: 121 (description; habitat; surface to 100 feet, average 30 feet; Newport Beach, La Jolla, and Santa Catalina Island, California; Los Coronados and Guadalupe Island, Mexico). Herald, 1961: 235-236, plate 101 (Catalina Island, California; fairly common; 20 feet and deeper). Roedel, 1962: 29 (common name, bluebanded goby). Pequegnat, 1964: 279, 280, table V (Corona del Mar, California; listed; population size on rock reef; habitat; most abundant fish on one reef—1,500 adults, 2,500 young). Carlisle, Turner and Ebert, 1964: 15, 28, 73, 77, table 1, Appendix A (observed on artificial reefs and offshore oil installations; spawned on Paradise Cove reef and on Redondo Beach artificial reef, California; average fish population consisted of 11.6% of the gobies *L. dalli* and *Coryphopterus nicholsii*, increased to 42.9% by December, 1960). Turner, Ebert and Given, 1969: 185-186, 208 (Appendix 3), 156 (table 5) (resident on artificial reefs at Hermosa Beach, Malibu, and Redondo Beach, California; observed on natural reefs from Santa Barbara to San Diego on mainland and at Santa Catalina, San Clemente, Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands, California; intertidal to at least 180 feet; general habits). Grigg and Kiwala, 1970: 152, table 2 (Palos Verdes Point, Los Angeles County, California; listed). Macdonald, 1972: 95, 98 (range—northern Gulf of California, Bahía Magdalena, Baja California, Mexico, to Morro Bay, California; cephalic-lateralis system). Miller and Lea, 1972: 186 (description; figure; key; range—Gulf of California to Morro Bay, including Guadalupe Island; intertidal to 210 feet; length to 2.25 inches). Herald, 1972: 209 (common inshore fish of California; coloration).

Diagnosis.—*Lythrypnus dalli* has a color pattern consisting of 4-9 narrow blue bands anteriorly, becoming narrower and fainter posteriorly. Lateral scales 38-54. Pectoral rays 17-20. Anal rays 12-15.

Description.—Body short, compressed. Greatest body depth 4.0-6.2 (4.84) in standard length. Body width 7.7-14.9 (11.31) in standard length. Head high and compressed; head width 1.3-2.2 (1.91) in head length; 3.5-5.1 (4.33) in standard length; blunt, profile rounded; snout short, 1.5-2.5 (1.87) in diameter of orbit. Orbit 2.4-3.8 (3.14) in head length. Mouth moderate, very oblique; lower jaw projecting; maxillary reaching about to under center of eye, 2.1-3.1 (2.66) in head length. Jaws with an outer row of long, distant canine-like teeth, and an inner row or a narrow band of minute teeth. Four large epipores above eye along the line of the supraorbital canal. A median crest extends from the dorsal forward to between the anterior margin of eyes, not extending onto head in smaller individuals. Dorsal VI, 16-19 (17.8); first dorsal spines much produced with lengthened filamentous rays, the longest reaching to beyond the middle of the second dorsal base when depressed; 1.5-4.7 (2.79) in standard length. Dorsal fins separate. Soft dorsal rather high, the fin long, 1.9-2.5 (2.26) in standard length. Anal 12-15 (14.3), somewhat shorter than second dorsal, 2.2-3.1 (2.62) in standard length.

Pectorals 17-20 (18.8); short, 3.0-3.5 (3.3) in standard length; upper rays not free or silk-like. Caudal 17, with 3 above and 3 below segmented, unbranched rays, and 11 segmented, branched rays; rounded. Pelvics free from belly, fully united; with 1, 5 rays. Scales ctenoid, of moderate size, covering entire trunk except nape; 38-54 (45.6). Color bright coral red, with 5-9 (6.3) narrow blue bands anteriorly, becoming fainter posteriorly. First bar extends from nape obliquely downward and forward ending on opercle, may be discontinuous; second blue bar runs from origin of first dorsal to behind pectoral base; third runs downward from between last two spines of first dorsal; remaining bars are under soft dorsal. Blue bars not reaching ventral outline. Marked with blue about eye: transverse interorbital blue bar, a continuation of which encircles the orbit; a blue band extends upward and posteriorly from each orbit, uniting on occiput; below orbit, a blue bar consisting of two portions, one dark triangle has its apex downward and obliquely backward across cheek, the other part upward and backward. In larger individuals, a blue streak runs along mid-dorsal line from occiput along profile to front of dorsal intersecting first body bar. Fins unmarked. Eye black. Alcoholic specimens are straw-colored with olive to dark brown bars.

ZEBRA GOBY

Lythrypnus zebra (Gilbert)

Gobius zebra.—Gilbert, 1890: 50, 73 (original description; off Santa Magdalena Island, Mexico; 36 fm.). Jordan and Evermann, 1896: 547 (west coast of Mexico; listed). Jordan and Evermann, 1898: 2226 (description; west coast of Mexico; 36 fm.). Jordan and McGregor, 1898: 284 (2 specimens from Todos Santos and Clarion islands, Mexico; coloration). Fowler, 1923: 293, 300 (Newport and Bird Rock, California).

Zonogobius zebra.—Snodgrass and Heller, 1905: 416, 425 (west coast of Lower California and Clarion Island, Mexico). Starks and Morris, 1907: 223-224 (first record north of southern part of Lower California, Mexico; specimens from San Clemente Island, California, 1 inch long; specimen from Todos Santos Islands, Mexico, 1½ inches long; description). Hubbs, 1916: 163-164 (24 specimens from San Clemente Island, California; variation from type; measurements and counts of 5 specimens; description). Ulrey and Greeley, 1928: 20 (San Clemente Island, Catalina Island and Newport, California, and Todos Santos and Guadalupe islands, Mexico). Jordan, Evermann and Clark, 1928: 441 (Pacific coast of Mexico and southern California). Ulrey, 1929: 10 (listed). Barnhart, 1936: 82 (description; Mexico to southern California; San Clemente Island, California).

Lythrypnus zebra.—Ginsburg, 1938: 115-116 (relationship between *Lythrypnus pulchellus* and *L. zebra*; differences in color patterns; the 2 populations tentatively recognized as distinct species; pectoral rays 19-20; southern California). Fowler, 1944: 517 (Mexico; listed). Hubbs and Follett, 1953: 34 (listed). Limbaugh, 1955: 120-121 (description; habitat; tide pools to 110 feet, average 27 feet; Newport Beach, La Jolla, and San Miguel, Santa Catalina, and Santa Cruz islands, California, and Los Coronados and Guadalupe Island, Mexico). Herald, 1961: 236 (description; common). Roedel, 1962: 29 (common name, zebra goby). Pequegnat, 1964: 279, table V (Corona del Mar, California; habitat; less common than *Lythrypnus dalli*; 200 individuals on reef). Best and Oliphant, 1965: 101 (Pt. Arguello, California; listed). Turner, Ebert and Given, 1969: 186, 208 (Appendix 3), 158 (table 5) (observed on Hermosa Beach, California artificial reef; resident; less numerous than *Lythrypnus dalli*). Grigg and Kiwala, 1970: 152 (table 2) (Palos Verdes Point, California; listed). Macdonald, 1972: 94-95 (range—Cedros Island, Mexico to Ventura County, California; cephalic-lateralis system indicates relationship between *Coryphopterus* and *Lythrypnus*). Miller and Lea, 1972: 186, 187 (figure; description; key; range—Clarion Island, Mexico, to Lion Rock, San Luis Obispo County, California, including Guadalupe Island, Mexico). Herald, 1972: 209 (Pacific North America; life colors). Quast, 1968: table 2 (northern into central temperate; 0-130 feet).

Diagnosis.—Color pattern consisting of 13-18 narrow blue bands becoming indistinct on lower parts of sides. Lateral scales 24-30. Pectoral rays 18-21. Anal rays 9-11.

Description.—Body short and compressed. Width of body 7.1-9.0 (7.95) in standard length. Greatest body depth 4.1-5.0 (4.48) in standard length. Head high, 2.3-4.4 (3.76) in standard length; blunt, profile rounded, somewhat compressed; head width 1.1-1.6 (1.44) in head length; snout short, 1.0-1.6 (1.31) in diameter of orbit. Orbit 3.0-4.1 (3.58) in head length. Mouth moderate, 2.2-3.2 (2.70) in head length; oblique, maxillary reaching below anterior third of orbit; lower jaw projecting. Teeth in a narrow maxillary band, outer series enlarged and spaced; and in wide mandibular band with a single series, similar to the outer row in upper jaw. No ridge or crest in front of dorsal. Interorbital very narrow. Four large epipores above the eye along the line of supraorbital canal. Dorsal VI, 11-14 (12.9); first dorsal spines filamentous in adults; last soft ray of dorsal and anal longest; dorsal fins separate; length first dorsal rays 2.6-4.6 (3.76) in standard length; length second dorsal rays 2.2-2.8 (2.60) in standard length. Anal 9-11 (10.0); length anal 2.5-3.3 (2.88); anal base somewhat shorter than base of second dorsal; upper rays not free or silk-like. Caudal 17; with 3 above and 3 below segmented, unbranched rays and 11 segmented, branched rays; rounded. Pelvics free from belly, fully united; 1, 5 rays. Scales ctenoid, with a row of apical spines; no scales on head, belly, or along base of spinous dorsal; 24-30 (26.1). Life colors cherry-red to brick-red ground color, with 13-18 (15.1) blue cross bars

on head and sides; blue bars half as wide as interspace in large specimens, relatively much wider in smaller specimens; blue bands darker than interspaces; on middle of interspaces a very narrow blue line, becoming indistinct on lower parts of sides; area on either side of cross-bands light in color. Blue bars encircle body except for a short distance on belly and underside of head; on upperside of head and nape these bars run obliquely forward and downward, but elsewhere are vertical; on cheeks blue bars are connected by narrow cross lines, forming blue reticulations surrounding spots of the red ground color. Bars in alcoholic specimens are olive brown with darker streaks along each border and near the center.

RANGE

Lythrypnus dalli ranges from Morro Bay (35°N), California (Macdonald, 1972), south along the coast of California, the California Channel Islands, the west coast of Baja California, and into the Gulf of California (Bahía de La Paz, 24°N; Carmen Island, 26°N; Isla Angel de la Guarda, 29°N), Mexico.

Lythrypnus zebra ranges from San Luis Obispo Co. (36°N), California, south along Baja California, into the Gulf of California and the west coast of Mexico, to Clarion Island (18°N) of the Revillagigedo Group.

Limbaugh (1955) noted that both species are commoner around the offshore islands than near the mainland, and postulated that this might be due to parasitization of the mainland population by an isopod. He found that nearly all specimens collected on the mainland were infected but those collected on the islands were not. In contrast, I found a low incidence of parasitic isopods on *L. dalli* (4.3% infected, n=909) and *L. zebra* (5.1%, n=314) at Punta Banda, whereas island populations (Todos Santos and Santa Catalina) were more heavily parasitized (*L. dalli*—15.1%, n=73; *L. zebra*—24.1%, n=29).

MERISTICS AND MORPHOMETRICS

Meristic variation was studied in *Lythrypnus dalli* populations of sampled areas (Table 1²). A trend toward higher dorsal and anal fin-ray counts occurred in the northern areas, whereas counts of pectoral rays and scales at midline showed an opposite trend. Fin-ray count modes of prejuveniles of *L. dalli* from Punta Banda were slightly lower than those of adults, perhaps due to delayed development of these elements.

Ginsburg (1939) and Böhlke and Robins (1960) have discussed the importance of color differences in identification of *Lythrypnus* species. Numbers of body bars and measurements of bar widths are included here with the morphometric and meristic data. Northern individuals had fewer body bars than southern gobies.

No notable trend of morphological variation was observed in the *L. dalli* populations sampled (Table 2²). The ratio of standard length to body width decreases irregularly from south to north. However, the Santa Catalina Island population showed narrower bodies than other northern populations. The ratio of standard length to head length increases slightly from south to north, although the Punta Banda population did not fit this trend. A south to north decrease in the ratio of length of eye to width of body bars was also noted.

Ginsburg (1939) designated *Lythrypnus latifascia* as a new species on the basis of it having wider cross bars, higher fin ray counts (D. 18, A. 14-15, P. 18-19) and longer dorsal fin spines than *L. dalli*. Morphometric data for *L. latifascia* (UCLA, SIO, SU) are presented in Table 3². Meristic data reveal considerable overlap between *L. dalli* and *L. latifascia*, although scale counts were strongly separated; anal fin-ray counts of *L. latifascia* are somewhat lower. I found that many individuals with wide body bars have meristics which by Ginsburg's description would characterize *L. dalli*; other individuals had narrow bars and the *L. latifascia* complement of serial elements. There was a significant difference in the width of body bars number 2 and 3 ($P < 0.001$ and $P < 0.05$, respectively) between

²Supplementary material; see bottom of page 170.

the Gulf of California *L. dalli* population and Santa Catalina *L. latifascia* specimens, but not between other sampled populations of *L. dalli* and *L. latifascia*. Means and ranges of the lengths of the first dorsal rays similarly show no distinction between *L. dalli* and *L. latifascia*. I found no behavioral or ecological differences which would support the separation into two species, and therefore have included *Lythrypnus latifascia* as a synonym of *L. dalli*.

Although only a small part of the range of *L. zebra* was examined the meristics in the sampled areas were rather uniform (Table 4²). Scale count modes of Punta Banda specimens were notably higher than those of more northern populations. Prejuveniles, possibly because of delayed development, had fewer scales and body bars than adults.

The morphological data for *L. zebra* are rather uniform and no basic trend in variation of body proportions was noted (Table 5²). The range of the standard length to head length ratio of the Punta Banda sample was far wider than the other populations sampled, although the ratio means were similar.

GENERAL ECOLOGY

Lythrypnus dalli and *L. zebra* were observed on the Punta Banda reefs at depths of 3 to 53 m. Limbaugh (1955) reported that *L. dalli* was found from the surface to 31 m (average depth 9.2 m) while *L. zebra* ranged from tide pools to 34 m (average depth 8.3 m). In the northern part (California) of the 2 species' sympatric range *L. dalli* is typically more numerous than *L. zebra* (Pequegnat, 1964; Turner et al., 1969; pers. obs.). Yet, at poison stations at Punta Banda, Mexico, I found *L. zebra* to be almost as numerous as *L. dalli*. Carl L. Hubbs (pers. comm.) noted that *L. zebra* was taken more commonly in poisoning operations at Isla de Guadalupe, Mexico. Apparently relative abundance of the two species varies greatly between areas, perhaps with *L. zebra* becoming proportionately commoner in southern parts of the ranges.

Both species prefer areas of rock reefs with little or moderate shell epibiose and particularly those areas that are not covered with algae or mosslike animals. The gobies remain near holes or cracks in the reef into which they retreat from

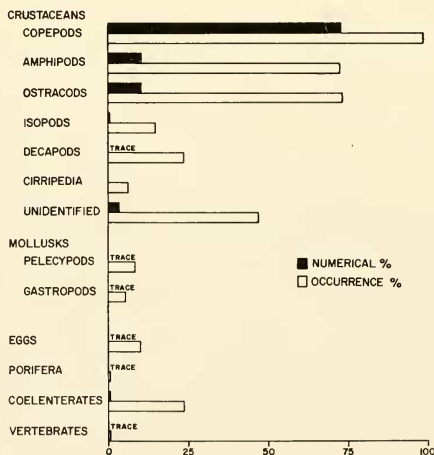


Figure 3. Analysis of 441 digestive tracts of *Lythrypnus dalli* collected at Punta Banda (NE), Baja California, Mexico, from September 1966 to September 1969.

danger. *Lythrypnus dalli* lives in crevices on the sides or upper surfaces of reefs and is commonly seen in exposed situations. *Lythrypnus zebra* prefers to remain under rocks, in caves, or far back in crevices and is less commonly observed. *Lythrypnus zebra* was frequently observed farther back in the same crevice or hole used by *L. dalli*. Pequegnat (1964) observed that *L. zebra* is characteristic of the middle-third of the reef while *L. dalli* is more often restricted to the reef base. I did not observe such distributional restrictions on the Punta Banda study reefs.

Both species are territorial and guard the shelter against intruders. In the aquarium, shelters were defended by the resident dashing out at the intruder, whereupon the latter would retreat. Occasional nip-and-chase sequences were observed in the laboratory and on the reefs.

Both species are brightly colored. *Lythrypnus dalli* appears particularly conspicuous to the human observer in its typical exposed position on a rock face. This raises the question of a possible aposematic function for the color pattern. However, during collections with Chem-Fish, poisoned individuals of *L. dalli* and *L. zebra* were frequently eaten by kelp bass (*Paralabrax clathratus*) and sheephead (*Pimelometopon pulchrum*). This suggests that these gobies are not distasteful.

FOOD HABITS

Food studies were conducted to identify the major foods, to determine if differences in seasonal utilization occurred, and to disclose any variation in the foods taken by different-sized fish. Two methods of analysis were used: numerical and

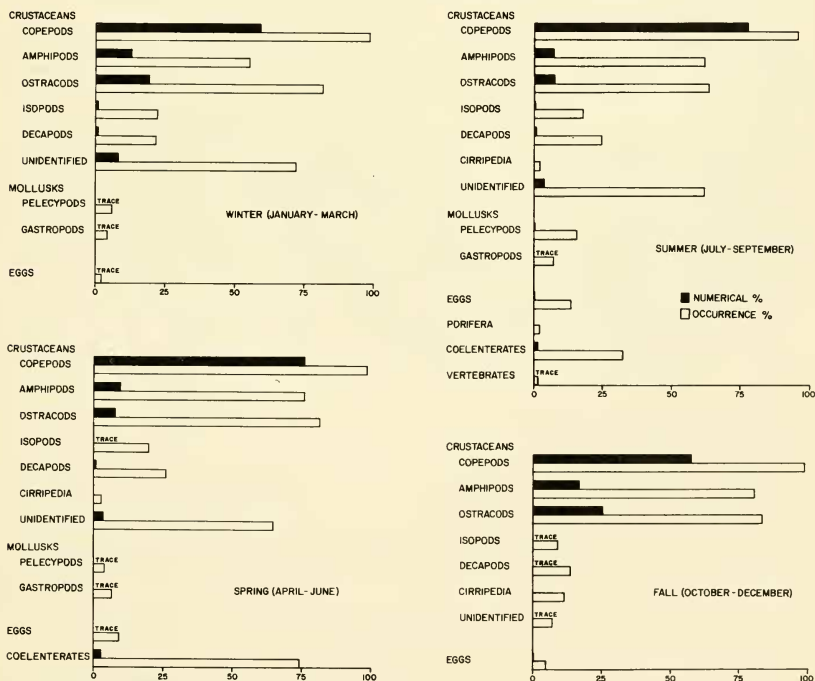


Figure 4. Seasonal analysis of the digestive tract contents of *Lythrypnus dalli*.

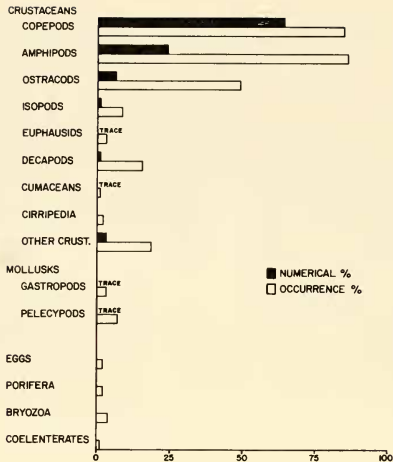


Figure 5. Analysis of 141 digestive tracts of *Lythrypnus zebra* collected at Punta Banda (NE), Baja California, Mexico, from September 1966 to September 1969.

frequency-of-occurrence. Stomach contents from 441 specimens of *L. dalli* and of 141 *L. zebra* collected at Punta Banda were analyzed.

Limbaugh (1955) reported that *L. dalli* feeds upon small crustaceans, including amphipods. I found that crustaceans comprised 98.5% of the items in the digestive tract (Fig. 3). Copepods were dominant, forming 72.4% of all items and being present in 97.2% of the stomachs examined. Ostracods and amphipods were next in importance, each forming 10.4% of the food items. Ostracods were found in 72.6%, and amphipods in 71.5%, of the stomachs examined. Other foods were generally in very small quantities. Only moderate seasonal variation was observed (Fig. 4). Copepods were found in the greatest numbers and in nearly every stomach examined during all seasons. Amphipods and ostracods became relatively more important in fall and winter. Coelenterates were taken in spring and summer, but were not found in the fall or winter samples. Occurrence of minor food classes (i.e. mollusks, eggs, vertebrates, sponges) increased during the summer season. No variation in diet between different-sized *L. dalli* was found.

Crustaceans are also the principal food item of *L. zebra* (Fig. 5), comprising 99.3% of the food items. Crustaceans were found in all stomachs examined. Copepods (63.1%), amphipods (24.2%), and ostracods (6.3%) were the most abundant crustaceans taken by *L. zebra*. Other foods (mollusks, bryozoans, and eggs) were found infrequently and in very small numbers.

Copepods were found in 85.1% of the stomachs (frequency-of-occurrence), amphipods in 86.3%, and ostracods in 49.0%. Very little seasonal variation was observed in the diet of *L. zebra*. Copepods and amphipods were the most important items during most seasons (Fig. 6). Copepods were taken more often than amphipods except in winter. Ostracods were of minor importance except in fall, when they were taken more frequently than amphipods. Several minor food classes (i.e. eggs, sponges, bryozoans, coelenterates) were noted during the summer only. No variation in diet between different-sized *L. zebra* was found, although sample size for younger individuals was too small for analysis.

Evidently, *L. dalli* and *L. zebra* depend primarily upon free-swimming or planktonic organisms and take benthic or burrowing forms only incidentally.

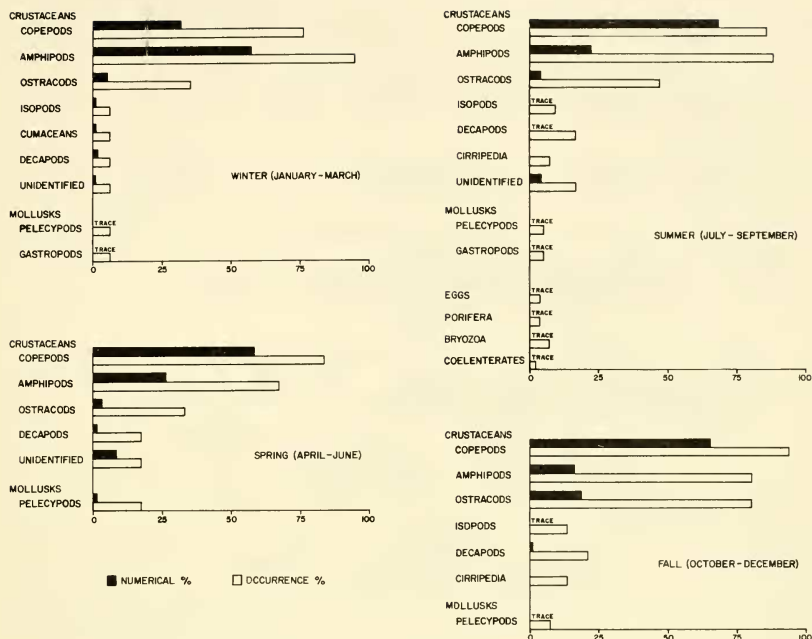


Figure 6. Seasonal analysis of the digestive tract contents of *Lythrypnus zebra*.

Feeding behavior of *L. dalli* consists of the goby swimming out from the reef about 1-5 cm, grabbing an item in midwater, and returning to its position on the reef. *Lythrypnus dalli* was also observed to selectively pick up such items as amphipods and small crabs from the substrate. The few observations that were made on the feeding behavior of *L. zebra* indicate this species takes most of its food from within the home shelter or directly in front of it. *Lythrypnus zebra* was only occasionally observed to feed in the open water in front of its shelter. In the aquarium both species preferred to take the food items (brine shrimp) as they drifted down through the water rather than pick them off the bottom.

PARASITES

Acanthocephalans are common internal parasites of both species of *Lythrypnus*. They were found in the guts of 54.5% (n=241) of *L. dalli* and 75.0% (n=106) of *L. zebra*. As many as 48 acanthocephalans were taken from one digestive tract. Other internal parasites were found infrequently. Nematodes were found in 0.7% of the digestive tracts of *L. dalli* and 3.5% of *L. zebra* guts.

Cymothoid isopods were occasionally found attached to the gills of *L. dalli* and *L. zebra* (see Range section).

POPULATION STRUCTURE

Samples from the *L. dalli* population at Punta Banda showed an adult sex ratio of 1 male to 1.61 females (228 males:368 females). In the juvenile sample (males: 13-22 mm; females: 13-21 mm), the ratio was 1:1.25 (97 males:121 females).

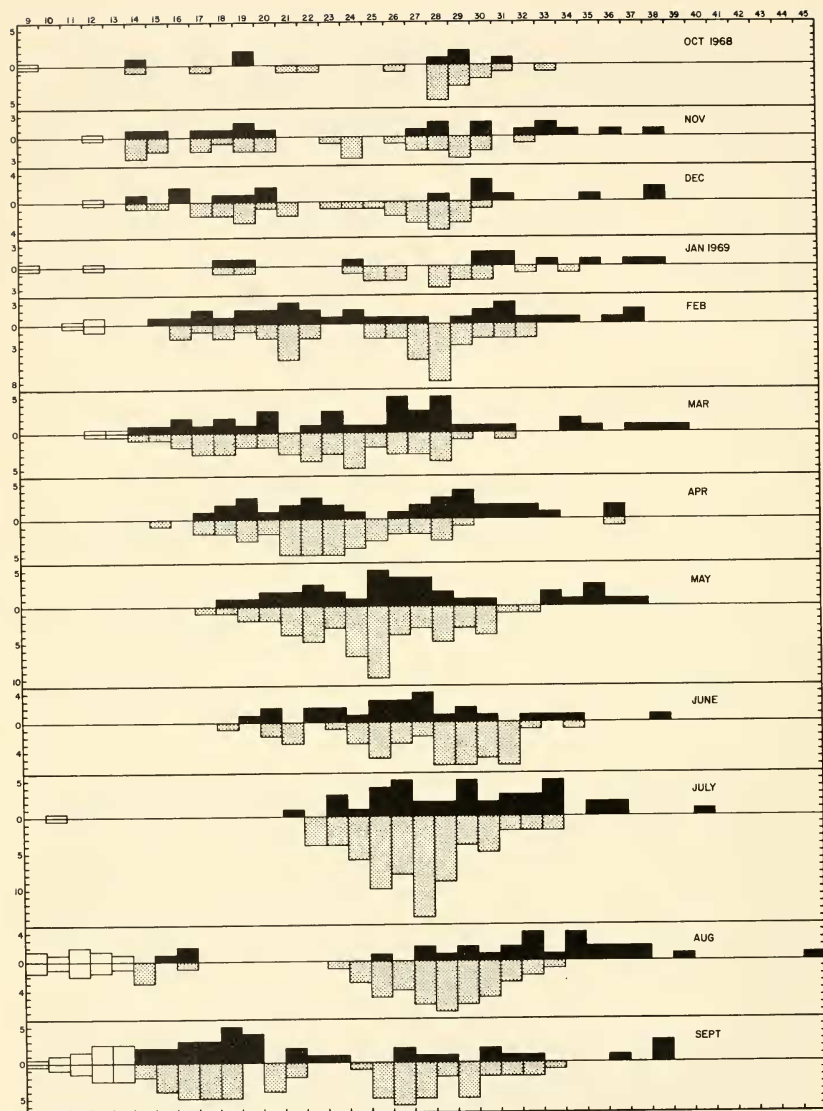


Figure 7. Length-frequency measurements of 852 specimens of *Lythrypnus dalli* taken at Punta Banda (NE), Baja California, Mexico, from October 1968 to September 1969. Clear boxes represent individuals in which sex was undetermined, solid boxes represent males, and half-tone boxes represent female individuals.

Length-frequency distributions of 852 *L. dalli* specimens indicate two age groups in most cases (Fig. 7) although overlap occurs, possibly due to the prolonged spawning period. *Lythrypnus dalli* breeds within the first year, and only a few individuals survive to the second year.

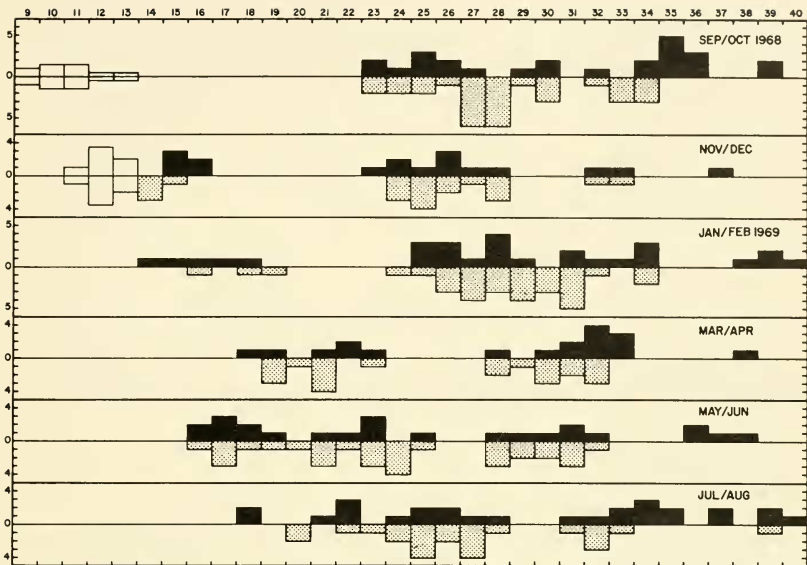


Figure 8. Length-frequency measurements of 314 specimens of *Lythrypnus zebra* taken at Punta Banda (NE), Baja California, Mexico, from September 1968 to August 1969. Legend as in figure 7.

Prejuvenile (less than 10 mm) *L. dalli* (transparent except for the bright blue bars) were observed on the Punta Banda reefs from mid-August to October. However, one 10 mm individual was observed on the reef on 17 July 1969. Pequegnat (1964) noted prejuvenile *L. dalli* on reefs at Corona del Mar, California, from September to November. The young gobies attain a length of 18-20 mm within four or five months.

The sex ratio of adult *L. zebra* collected at Punta Banda was 1:1.09 (125 males:136 females). The juvenile sample (males:14-18 mm; females:14-20 mm) showed a sex ratio of 1:1.14 (14 males:16 females).

Two age classes were indicated by length-frequency distributions of *L. zebra* (Fig. 8). *Lythrypnus zebra* breeds in the first year. Only a few individuals attain age two. Prejuveniles were not observed on the Punta Banda reefs until 14 September 1969, approximately one month later than *L. dalli* prejuveniles were observed on the same reefs.

REPRODUCTION

Nine hundred and nine *L. dalli* specimens from 9.2 to 45.3 mm were examined for reproductive condition. Ripe females were found at lengths greater than 22.0 mm on the Punta Banda and California reefs. However, female specimens from Gulf of California populations were found to be ripe at 19.0 mm and larger. Generally males from Punta Banda matured at lengths greater than 23.0 mm although two mature specimens measured 19.8 and 21.2 mm.

Ripe *L. dalli* were collected at Punta Banda from March through October (Fig. 9); the peak period of breeding activity was May through September. Limbaugh (1955) collected eggs on reefs in August and some were spawned in the lab during May. Postlarvae and young were collected by Limbaugh in March. Turner et al. (1969) reported that *L. dalli* eggs are laid in spring and early summer.



Figure 9. Monthly percentages of ripe *Lythrypnus dalli* from Punta Banda (NE), Baja California, Mexico. Based on 569 specimens greater than 23 mm S.L. taken from Punta Banda from October 1968 to September 1969. Solid dots (solid line) represent females, circles (broken lines) represent males.

They collected gravid females and their deposited eggs during August 1962.

Ripe *L. dalli* eggs ranged from 0.4 to 0.6 mm in diameter (mean 0.47 mm). Ovaries from 10 specimens contained an average of 1058 eggs (range 745-1593). Testes from 10 mature males averaged 9.2 mm long (range 8.0-10.1 mm).

Turner et al. (1969) observed *L. dalli* courtship and nest building during February 1963 in an aquarium containing three gravid females and a male. After first cleaning an area beneath a shell to receive the eggs, the male rushed at one female, nipping her genital area and jaws. Finally they locked jaws and drifted "leaf-like" about the tank. I observed similar chasing and nipping courtship behavior, but not jaw-locking displays, at Punta Banda between March and July 1968.

Spawned eggs were found in the empty mollusk shells of the reef epibiose, or, occasionally, in unattached shells on the bottom of the fish's shelter. The nest and eggs are guarded by the male only; he tends the eggs with fanning motions of the pectoral fins and rushes at intruders entering the nest territory.

Three-hundred and fourteen *L. zebra* specimens, varying in length from 9.8 to 41.5 mm, were examined for reproductive condition. At Punta Banda females were found to be ripe at lengths greater than 20.7 mm. Ripe males were found at lengths greater than 18.4 mm.

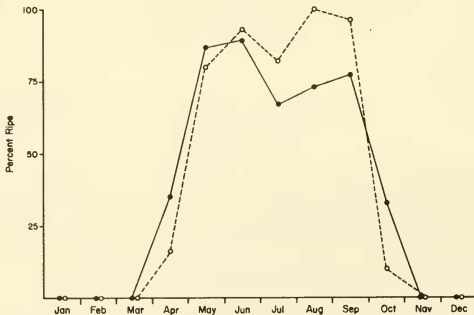


Figure 10. Monthly percentages of ripe *Lythrypnus zebra* from Punta Banda (NE), Baja California, Mexico. Based on 239 specimens larger than 19.0 mm S.L. (males) and 21.0 mm S.L. (females) taken from Punta Banda from September 1968 to August 1969. Solid dots (solid lines) represent females, circles (broken lines) represent males.

Table 6. Sexual dimorphism in fin measurements of *Lythrypnus dalli* and *Lythrypnus zebra*

Proportions	<i>Lythrypnus dalli</i>						<i>Lythrypnus zebra</i>					
	Males			Females			Males			Females		
	N	Range	Mean	N	Range	Mean	N	Range	Mean	N	Range	Mean
<u>standard length</u> length of longest 1st dorsal ray	40	1.6-2.5	(2.12)	51	2.6-4.4	(3.46)**	19	2.6-4.0	(3.39)	20	3.2-4.3	(3.95)*
<u>standard length</u> length base 1st dorsal	38	4.5-5.5	(4.95)	46	4.6-5.6	(4.98)	18	4.4-5.1	(4.80)	19	4.1-5.0	(4.57)
<u>standard length</u> length of longest 2nd dorsal ray	38	2.0-2.3	(2.17)	52	2.2-2.4	(2.31)	16	2.4-2.7	(2.56)	17	2.4-2.8	(2.64)
<u>standard length</u> length base 2nd dorsal	40	2.6-3.0	(2.82)	51	2.8-3.2	(3.00)	17	3.2-3.9	(3.59)	18	3.4-3.8	(3.59)
<u>standard length</u> length of longest anal ray	34	2.3-2.5	(2.28)	44	2.5-2.9	(2.74)*	15	2.6-3.0	(2.80)	16	2.8-3.3	(3.02)**
<u>standard length</u> length base anal	40	3.4-4.1	(3.72)	50	3.6-4.2	(3.96)	16	4.4-5.3	(4.82)	19	4.6-5.6	(5.08)

* $P < 0.05$ ** $P < 0.001$

Ripe *L. zebra* were collected at Punta Banda from April through October, the peak of sexual activity occurring between May and September (Fig. 10). Spawning eggs were found in July, August and September. Eggs were attached to the roof of the shelter or to empty mollusk shells within the shelter. The male guards the nest and cares for the eggs.

Ripe *L. zebra* eggs averaged 0.5 mm in diameter. Collective counts of mature eggs from both ovaries averaged of each of 10 specimens averaged 627 (range 293-1235). Testes of mature males averaged 6.1×0.9 mm (extremes 4.0×0.7, 8.6×1.3 mm) from nine individuals.

SEXUAL DIMORPHISM

Male *Lythrypnus dalli* attain a larger size than females. The mean length of 367 males and 542 females collected on the Baja California reefs was 22.8 mm; mean female length was 21.9 mm (maximum 34.0 mm), mean length of males 26.9 mm (maximum 45.3 mm). The greater size of the males may be important in nest defense.

In *L. dalli* the length of the first dorsal and anal fin-rays of mature individuals is significantly longer in males (Table 6). This dimorphism is not expressed in the length of the fin bases or in the meristic counts. The greater length of the dorsal and anal elements in males becomes evident at about 25-27 mm standard length. The tips of the first dorsal elements have bulb-like structures which are larger in males (Fig. 1). As with many species of gobies these fins are used in a variety of social displays and perhaps function in sex recognition.

Sexual dimorphism is also evident in the genital papilla (Fig. 11). *Lythrypnus dalli* can be sexed by the genital papilla at about 17 mm standard length.

Lythrypnus zebra males also attain a larger size than females. The mean length of the males collected on the reefs was 33.0 mm (maximum 43.7 mm), of females 29.4 mm (maximum 39.3 mm). The first dorsal and anal fin-rays are significantly longer in males (Table 6). *Lythrypnus zebra* can be sexed externally by the genital papilla at about 16 mm; the papilla is similar to that of *L. dalli* (see Fig. 11).

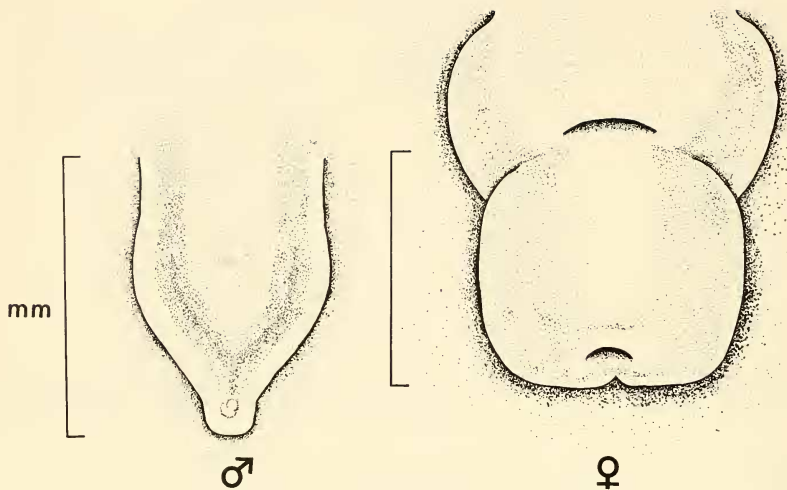


Figure 11. Sexual dimorphism in the genital papilla of *Lythrypnus dalli*. Male 37.3 mm, female 35.8 mm.

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